APPENDIX
A

Determine Size Using Sample Size Tables

In the process of collecting data, researchers need to determine the number of participants to use in their studies. Several options are available. They can make an educated guess as to how many people are needed, such as 10% of the population, which is somewhat arbitrary. They can ask as many people to participate as possible within the resources and time that both researchers and participants can provide. They can select a number that satisfies different types of statistical procedures, such as approximately 30 scores for each variable in a correlational analysis.

A more rigorous approach than any of these is to systematically identify the number of participants based on sample size tables available in published texts. To understand these tables, you need to understand the fundamentals of the formulas used. Two formulas are explained here: the sampling error formula and the power analysis formula.

This discussion on the two formulas builds on earlier comments about the importance of systematically calculating sample size using formulas in quantitative research. This importance was introduced in Chapter 5 in the "Sample Size" section and reinforced in Chapter 10 on experimental designs under "Step 3. Select an Experimental Unit and Identify Study Participants." It was also mentioned in Chapter 11 on correlational designs, although sample size is often dictated by the required size for making assumptions about the normality of the distribution of scores. (See Chapter 11's discussion of size in correlation studies in "Step 2. Identify Individuals to Study.") However, a sampling error formula may be used when the intent of the correlational study is to generalize from a sample to a population. Using a formula was also encouraged again in Chapter 12 on survey designs in "Step 3. Identify the Population, the Sampling Frame, and the Sample." Here, we explore the calculations involved in the sample size formulas and present tables that simplify the process of making the calculations.

SAMPLING ERROR FORMULA

A sampling error formula is often used in survey or correlational research (see Fink, 2013; Fowler, 2014) when investigators seek to generalize results from a sample to a population. A **sampling error formula** is a calculation for determining the size of a sample based on the chance (or proportion) that the sample will be evenly divided on a question, sampling error, and a confidence interval.

The formula is based on the proportion of the sample that will have the desired characteristic you are trying to estimate. For example, when parents are polled to determine whether they would vote "yes" or "no" on a school bond issue, there is a 50/50 chance that they will vote "yes." Selecting a proportion of 50/50 means that the population will be evenly split, and this proportion yields the largest size for your sample.

The sampling error formula is also based on stating the amount of sampling error you are willing to tolerate. Recall that sampling error (stated as a percent, such as from 4% of the time) is the difference between your sample mean and the true population mean. This error results because samples are randomly selected from the population and may not represent the true characteristics of the population (see Chapter 5). Finally, the formula also includes identifying a confidence interval, such as a 95% confidence interval. Recall that a confidence interval indicates the upper and lower values that are likely to contain the actual population mean (see Chapter 6).

Understanding these three factors helps you interpret a sample size formula table, such as Table A.1 by Fowler (2009, p. 41). The first row in this table shows the percentage of the sample with the desired characteristic, ranging from 5/95 (small chance) to 50/50 (equally split chance). To maximally divide the sample, researchers typically select 50/50 as the proportion of the sample with

TABLE A.1

Fowler's (2009, p. 41) Sample Size Table: Confidence Ranges for Variability Due to Sampling*

	Percentage of Sample with Characteristic				
Sample Size	**5/95**	**10/90**	**20/80**	**30/70**	**50/50**
35	7	10	14	15	17
50	6	8	11	13	14
75	5	7	9	11	12
100	4	6	8	9	10
200	3	4	6	6	7
300	3	3	5	5	6
500	2	3	4	4	4
1000	1	2	3	3	3
1500	1	2	2	2	2

Note: Chances are 95 in 100 that the real population figure lies in the range defined by the +/– number indicated in table, given the percentage of sample reporting characteristics and number of sample cases on which the percentage is based.
*This table describes variability due to sampling. Errors due to nonresponse or reporting errors are not reflected in this table. In addition, this table assumes a simple random sample. Estimates may be subject to more variability than this table indicates due to the sample design or the influence of interviewers on the answers they obtained; stratification might reduce the sampling errors below those indicated here.
Source: Fowler, F. J. *Survey Research Methods*, p. 41. Copyright © 2009. Reprinted by permission of SAGE Publications, Inc.

the characteristic they are trying to estimate. In terms of the confidence interval, this table reports only a 95% confidence interval (default), which means that 95 out of 100 times the sample mean will fall within the upper and lower limits, or range, of the population mean. This is a rigorous standard to use. In the columns under the heading "Percentage of Sample with Characteristic," we see values such as 17, 14, and 12 under the "50/50" column. These values are the amount of sampling error we are willing to tolerate. Typically, researchers set a small error that they are willing to tolerate, such as 4% or 6%. This means that only 4% or 6% of the time the sample mean will differ from the true population mean. Finally, in the left column, we see the sample size recommendation that you would use as a guide to the minimum size for the sample in your study.

Let's apply information from this table to a study to see how it works. Assume that you need to determine the size of your sample in a study of Native American students in a school district. You want to survey students in high schools in a large metropolitan district to determine if students plan to enroll in advanced placement courses ("yes" they plan to enroll, "no" they do not plan to enroll). The procedure needs to be as rigorous as possible, so you decide to use Fowler's (1988) table to calculate the sample size for your study.

A given in Fowler's (2009) table is that you will use a rigorous confidence interval standard—a 95% confidence interval (upon repeated sampling, 95 out of 100 times your sample value will fall within the range of the population mean). You assume that students have a 50/50 chance of participating in these courses. Based on this information, you select the column "50/50." Furthermore, you want a low error rate—a small percentage of the time your sample mean will differ from the population mean. You select an error of 4% (4 out of 100 times).

To identify the appropriate sample size you need in your study, you look at the last column ("50/50"), go down the column to "4" (4%), and then look across the row and find that the ideal sample size is 500 Native American students. This number, based on the sample size formula, will ensure that 95 out of 100 times (95% confidence interval), your sample mean will have an equal chance (50/50 split) of differentiating among the students 96% of the time (or an error of 4%).

TABLE A.2

Lipsey's (1990, p. 137) Sample Size Table: Approximate Sample Size per Experimental Group Needed to Attain Various Criterion Levels of Power for a Range of Effect Sizes at Alpha = .05

	Power Criterion		
Effect Size	.80	.90	.95
.10	1570	2100	2600
.20	395	525	650
.30	175	235	290
.40	100	130	165
.50	65	85	105
.60	45	60	75
.70	35	45	55
.80	25	35	45
.90	20	30	35
1.00	20	25	30

Source: Lipsey, M. W. *Design Sensitivity: Statistical Power for Experimental Research,* p. 137.

POWER ANALYSIS FORMULA

In many experiments, the size of the overall number of participants (and participants per group) is dictated by practical issues related to the number of volunteers who enroll for the study or the individuals who are available to the researcher. Researchers can also use statistics to analyze the data, and these statistics call for minimum numbers of participants for each group when group comparisons are made.

A rigorous, systematic approach is to use a power analysis. A **power analysis** is a means of identifying appropriate sample size for group comparisons by taking into consideration the level of statistical significance (alpha), the amount of power desired in a study, and the effect size. By determining these three factors, you can look up the adequate size for each comparison group in an experiment and use tables available in published texts (e.g., Lipsey, 1990). As shown in Table A.2, the process works this way.

- First identify the statistical level of significance to use in testing your group comparison hypothesis, typically set at $p = .05$ or $p = .01$. (See Chapter 6 discussions on hypothesis testing.)
- Next, identify the power needed to reject the hypothesis when it is false, typically set at .80. (See Chapter 6 discussions on types of outcomes of hypothesis testing.)
- Determine the effect size, which is the expected difference in the means between the control and experimental groups expressed in standard deviation units. This effect size is often based on expectations drawn from past research and is typically set at .5 for much educational research (Murphy, Myors, & Wolach, 2014). (See Chapter 6.)
- Go to a table for calculating the size of the sample given these parameters and identify the size of each group in the experiment. This size becomes the number of participants you need for each group in your sample. The approximate sample size per experimental group with an alpha set at .05 is given in Table A.2 (Lipsey, 1990, p. 137).

Let's take an example to apply the power formula and Lipsey's table. Assume that elementary education children identified as gifted in a school district are assigned to one of two groups. One group receives an enrichment program (the experimental group), and the other group receives traditional instruction (the control group). At the end of the semester, both groups are tested for creativity. How many gifted students are needed for both the experimental and the control groups? We might use the number of students available and equally assign them to groups. Although

such an experiment could be made, we want a sufficient number of students in our groups so that we can be confident in our hypothesis test of no differences between the control and experimental groups.

In other words, we need an experiment with sufficient size to have power (see Table 6.8 on possible outcomes in hypothesis testing). We turn to Lipsey's (1990) power analysis table for assistance in determining the appropriate sample size for our experimental and control groups. This table will indicate the size needed given a confidence level, the amount of power desired, and the effect size. Examining Lipsey's table, we find that the significance level for the table is set at an alpha = .05.

We use a rigorous standard for power, such as .80 (80% of the time, we will reject the null when it is false) and select the column ".80." Then we look at the column for effect size and choose ".50" as the standard for differences in the means (in standard deviation units) that we will expect between the two groups. Using this information, and going down the column of .80 to the row .50, we find that 65 students are needed for each of our two groups, the experimental and control groups, in our study of gifted children.

In addition to using tables, such as Table A.2, we can use computer applications to conduct a power analysis. G*Power is a free program offered for both Windows and Mac (gpower.hhu.de/en.html). G*Power allows you to select from common statistical tests (e.g., *t*-tests, *F*-tests, chi-square tests, etc.), specify a desired power such as 80%, and calculate the needed sample size (Faul, Erdfelder, Buchner, & Lang, 2009).